May 25, 2020

Mary Nichols, Chair
California Air Resources Board
1001 I Street
Sacramento, CA 95814

RE: Comments on Proposed Advanced Clean Truck Regulation

Dear Chair Nichols and Members of the Board,

Thank you for the opportunity to comment on the California Air Resources Board's (CARB's) proposed Advanced Clean Trucks (ACT) regulation. I recommend against adoption of the proposed regulation for the reasons listed below, with each rationale offered in response to specific justifications listed in CARB Staff's *Advanced Clean Trucks Fact Sheet*. Detailed explanation of these points follows this summary.

ACT Fact Sheet: Mobile sources and the fossil fuels that power them are "responsible for approximately 80% of smog-forming nitrogen oxide (NOx) emissions."

> **Counterpoint:** The last 15 years of air quality data indicate that the current imbalanced NOx reductions are delaying Californias' ozone attainment. Adopting the proposed ACT regulation will further delay California's ozone attainment by generating an even more imbalanced atmospheric NOx reduction. (see counterpoint 1 below)

ACT Fact Sheet: Displacement of fossil fuels by zero-emissions vehicles (ZEVs) is an ozone mitigation solution.

> **Counterpoint:** California ozone violations actually increased during the most recent recession when gasoline and diesel fuel usage was reduced by 2-4 billion gallons, the equivalent of replacing 5.7-10.5 million light-duty internal combustion engine (ICE) vehicles and 80,000 Medium- and Heavy-Duty (MHD) ICE vehicles with ZEVs. (see counterpoint 2 below)

ACT Fact Sheet: "When [ZEVs are] compared to diesel vehicles, they are two to five times more energy efficient"

> **Counterpoints:** MHD ZEVs are actually only 10-40% more efficient than their diesel counterparts when including energy losses of power plants, battery chargers, and batteries as required in the proper Well-to-Wheels efficiency statement for ZEVs. (see counterpoint 5 below) Furthermore, due to the added battery weight, some MHD ZEVs cannot carry the same payload as their diesel counterparts. ZEVs' lower cargo weight limit increases trips, emissions, and energy use for the same goods movement.

ACT Fact Sheet: ZEVs are needed to reduce particulate matter (PM) pollution and, more specifically, toxic diesel PM emissions, 95% of which are emitted by petroleum-fueled mobile sources.

> **Counterpoints:** Today's cleanest diesel vehicles provide greater localized PM reductions than ZEVs. On-road toxic diesel particulate matter was addressed nationwide in 2007 by diesel soot filters which remove greater than 99.7% of diesel soot. (see counterpoints 3 and 4 below)

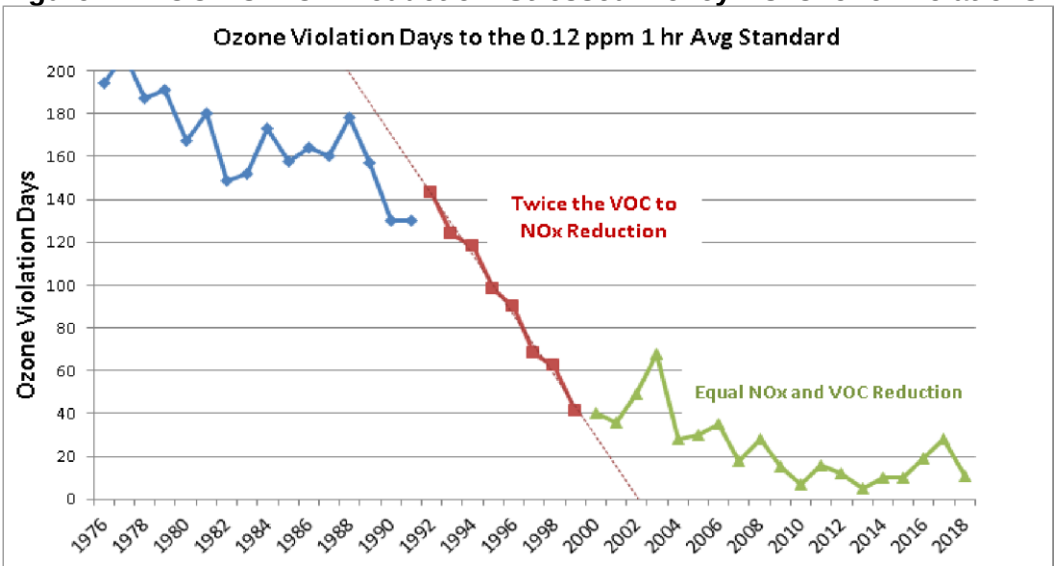
ACT Fact Sheet: ZEVs "reduce GHG emissions substantially."

Counterpoint: Vehicles fueled with renewable diesel (RD) and biodiesel (BD) reduce GHG levels at least 3.5 times faster, and at similar per-vehicle rates as ZEVs without requiring a new vehicle or fueling infrastructure. This is especially true for diesel vehicles driven the most annual miles. (see counterpoint 5 below)

Counterpoint 1. NOx Reductions Since 2000 Have Delayed Ozone Attainment

As seen in Figure 1, below, greater NOx reductions have delayed attainment of the federal ozone standards in the South Coast Air Basin (SCAB). In the 1990s, when more VOC reductions occurred, great ozone violation progress was made. After California environmental policy shifted focus from reducing VOC to reducing NOx, ozone violation progress was significantly delayed.

Figure 1. VOC vs NOx Reduction Stressed Policy vs Ozone Violations for the SCAB

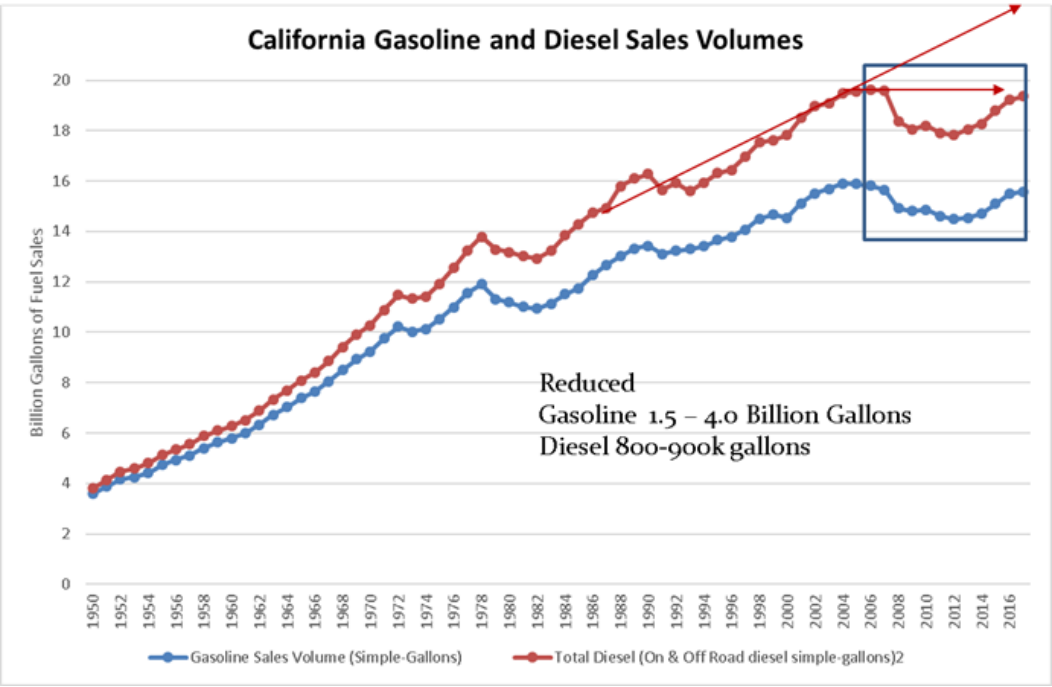


Source: *AQMD Historic Air Quality Data https://www.aqmd.gov/home/air-quality/historical-air-qualitydata/historic-ozone-air-quality-trends.* ***Assertions in Red and Green Text:*** *Bart Croes, CARB. The Ozone "Weekend Effects" and NOx Control Strategies, Scientific and Public Health Findings and Their Regulatory Implications, EM Forum, July 2003.*

Before adopting the proposed ACT regulation, the Board should re-examine why ozone violations increased in Southern California during the recession years (2009-2014), which reduced fuel sales by 2-4 billion gallons per year – the equivalent of replacing 5.7-10.5 million ICE vehicles with ZEVs statewide.

Figure 2, below, shows the fuel sales decline mentioned above from the peak year and relative to historic growth.

Figure 2. California Gasoline and Diesel Sales Volumes Highlighting the Recession Reduced Fuel Sales Period



Source: California Energy Commission / California Department of Tax and Fee Administration: https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts.htm

Several atmospheric scientists performed extensive atmospheric analysis in the early 2000s, concluding that California's aggressive NOx reduction policy used in the SCAB[1] was responsible for greater ozone violations occurring on weekends.[2] The atmospheric scientists further concluded that continuing aggressive NOx reductions would, at a minimum, *delay* ozone attainment and, at worst, actually *increase* ozone levels. The CARB Board should re-examine the increasing ozone violations in the SCAB over the last five years despite 70 percent lower atmospheric NO_2 levels compared to the 1990s.[3] (see Figures 1, 3, and 4)

Furthermore, engines suffer a fuel economy penalty for NOx control. Legislated NOx reductions implemented since the mid-1990s have increased fuel consumption for all gasoline and diesel vehicles, recent hybrid vehicle developments cite 15-17% increased fuel consumption.[4] Assuming a conservative 2-4% fuel economy loss, California drivers are consuming over 0.5-1 billion

[1] SCAB is generally a volatile organic compound (VOC) limited air basin, consequently NOx reductions increase ozone formation. VOC limited air basin produce less ozone with VOC reductions and NOx increases. NOx reductions tend to increase ozone formation as confirmed by the Weekend Ozone study, and 15-years of ambient measurements.

[2] In 2003, 9 Papers were published in the Journal of the Air Waste and Management Association. The Weekend Ozone Effect – See Also The Weekly Ambient Emissions Control Experiment, Doug Lawson, July 2003 EM Forum

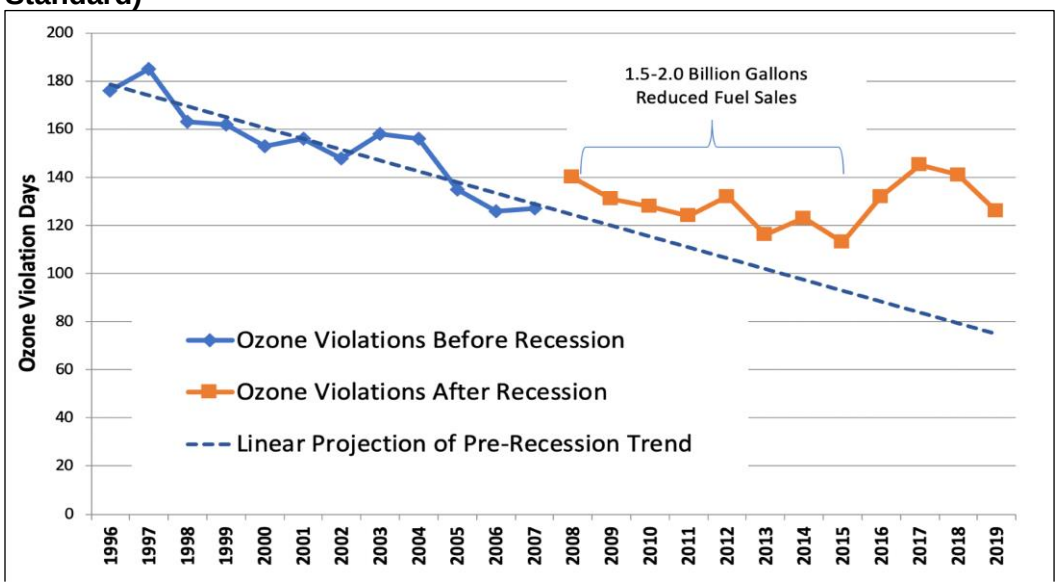
[3] NO_2 readings from EPA Air Quality Trends by City, 1990-2018, and Anaheim-Pampas Lane Station.

[4] 10% Fuel Economy Loss: Argonne National Laboratory, Trade-Offs Between Fuel Economy and NOx Emissions Using Fuzzy Logic Control With a Hybrid CVT Configuration. Aymeric Rousseau
17.4% Fuel Economy Loss: Fuel Economy and NOx Emission Potential Investigation and Trade-off of hybrid electric vehicle based on Dynamic programming, G-Q Ao, 1030, 2008.

gallons, and emitting 4.4-8.8 million metric tons CO_2 annually due to CARB's NOx-reduction requirements.

Figure 3 shows that SCAB ozone violations increased during the 2009-2014 period in which usage of petroleum-based fuels declined due to the recession. This finding runs contrary to CARB's clean air quality theory and the proposed ACT regulation's objectives.

Figure 3. Ozone Violation Days in SCAB Before and After Reduced Fuel Sales (2015 Federal Standard)



Source: AQMD Historic Air Quality Data [*https://www.aqmd.gov/home/air-quality/historical-air-qualitydata/historic-ozone-air-quality-trends*](https://www.aqmd.gov/home/air-quality/historical-air-qualitydata/historic-ozone-air-quality-trends)

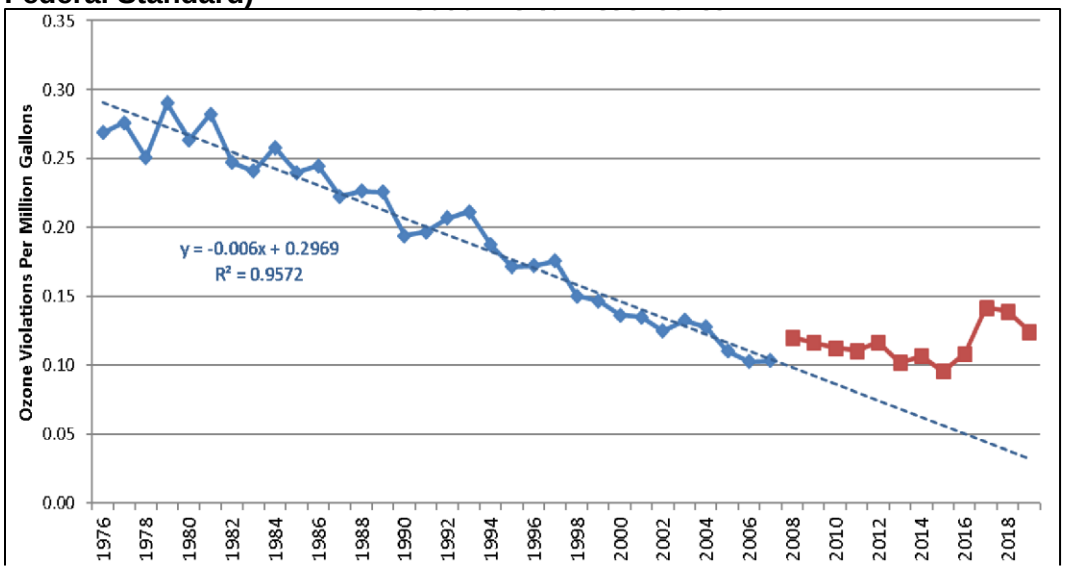
As can be seen in Figures 1, 3, & 4, California has more than 15 years of empirical evidence that indicates CARB's strong NOx reduction policy has delayed ozone attainment relative to the performance seen in the 1990s. This finding contradicts the reasoning for CARB's ongoing NOx-reduction policy and the proposed ACT regulation. Since the 1990s, CARB's policy shifted from an emphasis on reducing Volatile Organic Compounds (VOC) to aggressively reducing NOx emissions. According to historical ozone violations data, this emphasis on NOx-reduction policy is delaying ozone attainment in the SCAB by over 15 years. If CARB had instead maintained their 1990 environmental policies, SCAB would have been in attainment to the 0.12 parts per million (ppm) ozone standard 15 years ago (as shown in Figure 1 above). The ozone attainment delay since the 1990s has been observed for all four ozone standards.

Counterpoint 2. Ozone Violations *Increased* with a 2-4 Billion Gallon Decline in Gasoline and Diesel Sales

Foundational to the reasoning behind the push for MHD ZEVs is CARB's statement that vehicle emissions are "responsible for approximately 80 percent of smog-forming nitrogen oxide (NOx) emissions."[5] As shown in Figure 2 above, between 2009-2014, gasoline and diesel fuel sales *declined* by an unprecedented 2-4 billion gallons per year[6] due to the recession. Diesel fuel sales declined 20 percent (800,000 gallons per year from the 2007 peak year), representing the equivalent of replacing 80,000 heavy duty (HD) ICE vehicles with ZEVs. Gasoline sales declined by 11 percent (1.5 billion gallons per year from the 2004 peak year), representing the equivalent of replacing 5.7 million light duty (LD) ICE vehicles with ZEVs.[7] Gasoline sales declined by 5 billion gallons per year from the historic growth trend, representing 10.5 million LD ICE vehicles with ZEVs. During this period of declining gasoline and diesel usage, ozone violation days *rose*. Given these data points and CARB's goal of decreasing ozone violation days, the Board and Staff would be wise to consider how adopting the ACT, thus reducing diesel fuel use as happened during the recession, may similarly increase ozone violation days rather than decreasing them.

Looking specifically at the decline in petroleum-based fuel sales leading to increased ozone violations, Figure 4 shows the annual SCAB ozone violation days to the 2015 federal ozone standard divided by gallons of gasoline and diesel fuel sales. This analysis also reveals the counterintuitive ozone trend – ozone violation increased when fuel sales decreased. One justification for the passage of the ACT is that reduced petroleum-based transportation fuel use would *decrease* ozone levels. Historical data does not bear out this conclusion.

Figure 4. Ozone Violation Days per Million Gallons of Gasoline and Diesel Sales (2015 Federal Standard)



Sources: AQMD Historic Air Quality Data, CEC Transportation Fuel Supply Outlook (2017), and CDTFA

[5] CARB, Advanced Clean Trucks Fact Sheet, July 2, 2019, https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-trucks-fact-sheet

[6] Gasoline and diesel fuel sales declined up to 2 billion gallons from the 2007 peak fuel use year and declined by 4 billion gallons relative to historic fuel growth trends.

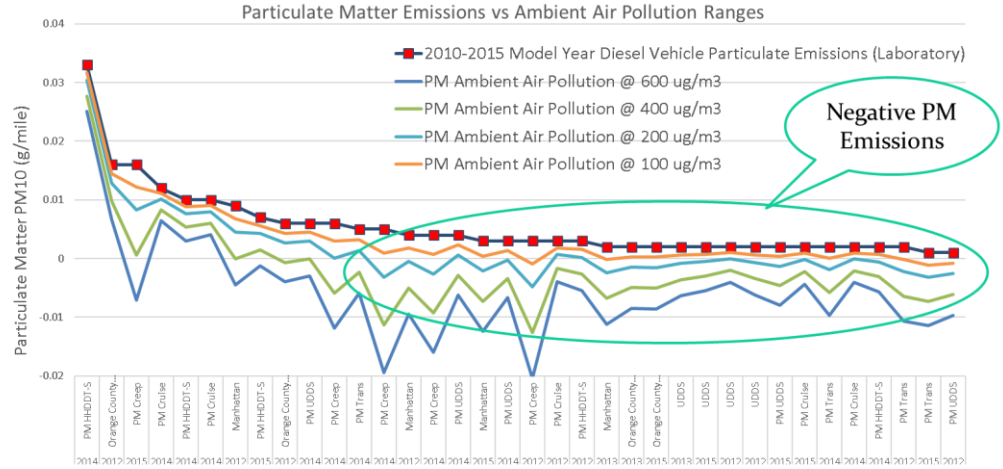
[7] Light Duty ZEV population equivalent estimated using the California Energy Commissions' Light -Duty Plug-in Electric Vehicle Energy and Emission Calculator. https://ww2.energy.ca.gov/sb350/IRPs/index.html

Counterpoint 3. CARB's Analytics Have Errantly Determined Surplus ZEV Criteria Emission Reductions

CARB Staff state that MHD ZEVs are cleaner than MHD diesel vehicles. Staff uses a high emission estimate based on a population and age weighted-average diesel vehicle emissions comparison with ZEVs. This is a false comparison metric to determine "surplus" emission reductions given the advances in ICE pollution containment. Today, there are a number of super-clean[8] diesel and natural gas vehicle models certified and operating on the roads.[9] These super-clean models are representative of new vehicles which would be placed in service in CA in the absence of the proposed ACT regulation. The super-clean diesel and natural gas vehicle populations and their annual miles traveled should be used as the basis for comparison to the MHD ZEV when determining if ZEVs create "surplus" emission reductions since the older fleet would be turned over into a super-clean fleet over time in the absence of the ACT.

The error CARB and EPA Staff make in estimating MHD vehicles' on-road criteria pollution to the atmosphere is due to using unadjusted laboratory emission testing protocols for estimating on-road vehicle emissions. CARB and EPA have not updated emission testing protocols to account for new emission technology employed nationwide since 2007 reducing some criteria pollutants by 95-99.9 percent. Laboratory emission testing excludes the fact that all MHD diesel vehicles consume air.[10] Laboratory tested vehicles are tested in filtered, zero-pollutant air. In the real world, however, vehicles operate in environments with ambient air pollution and at times may produce exhaust lower in criteria pollutants than the ambient air they take in. Figure 5, below, shows several super-clean diesel vehicles' laboratory results and adjusted test results including the on-road air pollution consumption and clean-up. Similar results are also found for VOC and CO pollutants. Battery-powered ZEVs powered by renewable electricity do not clean the air relative to these super-clean vehicles.

Figure 5. HD Diesel Vehicle Laboratory PM Emission Test Results and Adjusted Values with the Inclusion of On-Road



Source: Altoona Bus Emission Test Facility and CeCERT adjusted for air consumption and pollution mass.

[8] Super-clean diesel and natural gas vehicles are the cleanest model-year vehicles based on their ultra-low certification emission values and/or ultra-low vehicle emission testing performance seen by chassis dynamometer testing facilities.

[9] One example of Super-Clean Diesels, since 2010 model-year roughly 15-20% of ARB New Vehicle MHD Certification values are certified at zero; VOC, CO, or PM_{10} emissions.

[10] All MHD diesel vehicles consume 81 m^3 +/-11.2 m^3 of air per diesel gallon consumed, per Cummins Engine Company Data which logged 97 MHD trucks operating on-road in various vocations.

Examining the $PM_{2.5}$ weighted average mean (WAM) and (98^{th}%) from EPA's *Air Quality Trends by City*, before and after the recession's reduced fuel sales for the LA area, generally does not find $PM_{2.5}$ trend changes with more or less vehicles. As CARB emission inventory states, mobile sources represent 2-4% of the statewide total $PM_{2.5}$ inventory. Recent tunnel studies find the majority of on-road PM is from non-vehicle sources including windblown dust. Today, vehicle-created re-entrained road dust, road wear, and tire wear are the larger mobile source of PM regardless of powertrain used.

Accounting for the fact that all diesel engines consume air and that there is air pollution on the road, the laboratory emission tests overestimate modern (properly operating) on-road vehicle emissions for VOC and PM_{10} by 17 percent and 38 percent respectively. The cleanest HD diesel vehicles tested at Altoona or CeCERT laboratories are estimated to have 70-85 percent lower emissions when operated in air quality exceeding ambient air quality standards found in Los Angeles in 2018 for PM_{10}. In some acute hot spot locations and times, the cleanest MHDs provide negative emissions (i.e. the tailpipe emissions are lower than the ambient air). Accounting for diesel vehicles' filtering of ambient air pollution would decrease CARB's PM emission estimates for petroleum-fueled MHD vehicles by 38%. By contrast, CARB projects just 3-11 percent PM reduction by 2040 from the ACT.

Counterpoint 4. ZEV Driving Range Must Nearly Match That of Diesel Counterparts to Break Even on Criteria Pollutant Reductions

The proposed ACT regulation does not properly account for the critical fact that MHD ZEVs provide no criteria pollutant reduction benefits until the MHD ZEVs provide greater than 97 percent of the daily vehicle miles traveled (VMT) of the new diesel counterpart displaced. This determination was made by comparing emission reductions from current new and used vehicles tested at CeCERT and Altoona Bus Emission Test Facilities that retire a 2000 model-year HD diesel using the 2014 Emission Factor for Mobile Sources (EMFAC) emission rates. (see Table 1) Note: This analysis assumes zero-pollutant electricity generation for the MHD ZEV. Based on the 2014 EMFAC criteria emission displacement break-even estimate, the ACT, if adopted, should only provide ZEV credits for MHD ZEVs used in applications and vocations that the ZEV can demonstrate, for the vehicle's useful life, daily equivalent VMT to the displaced MHD internal combustion vehicle.

Table 1. Emissions Break-Even Analysis for Replacing a 2000 Model-Year Diesel Vehicle

How many miles must a HD ZEV drive to break-even with the emission reductions of a new diesel replacing a 2000 MY diesel?			
Emissions	**Lab Only**	**Clean On-Road Air Operation**	**Comments**
Particulate Matter	99.8%	99.9%	Diesel or Renewable Diesel
Hydrocarbons	99.5%	99.8%	Diesel or Renewable Diesel
Carbon Monoxide	99.2%	99.8%	Diesel or Renewable Diesel
0.09g/NOx (20% of engines)	98.2%	98.2%	Diesel or Renewable Diesel
0.15g/NOx (41% of engines)	97.1%	97.1%	Diesel or Renewable Diesel
CO2e Ca Average (295 g/kwh)	89.8%		Renewable Diesel
CO2e Ca Average (295 g/kwh)	95.3%		30% Better MPG Hybrid & Renewable Diesel
CO2e Ca Min (97 g/kwh)	73.7%		Renewable Diesel
CO2e Ca Min (97 g/kwh)	74.8%		30% Better MPG Hybrid & Renewable Diesel
Assuming: Replacing a 2000 MY Diesel (@ ARB EMFAC emissions rates) with a 2019 MY Diesel or HD ZEV, 42,000 miles, 6.0 mpg HDD			
Zero Power Generation Criteria Pollutant Emissions for HD ZEV power			

Before adopting the ACT legislation, CARB should properly account for the super-clean diesel vehicles' minimized emissions, air-cleaning capacity in ambient air violation areas, and their greater population and greater miles driven then perform a comparison with MHD ZEVs to determine if "surplus" emission reductions do indeed occur.

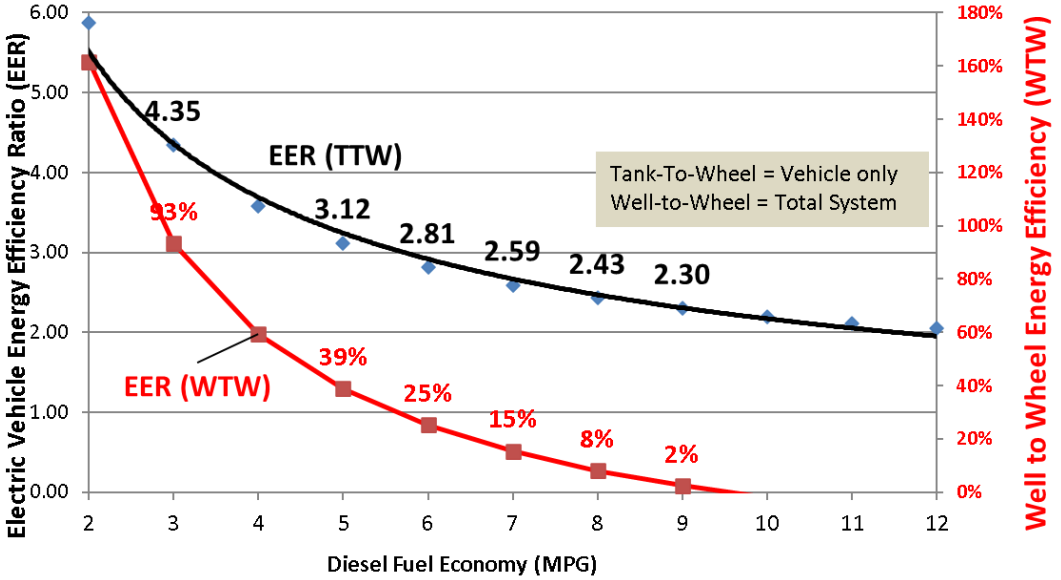
Counterpoint 5. ZEVs' Energy Efficiency and CO_2 Reductions Are Overestimated

CARB's *ACT Fact Sheet*, mischaracterized the energy economy ratio (EER) for MHD vehicles, citing MHD ZEVs as having 2-5 times higher energy efficiency based on Tank-to-Wheel (TTW) values. The correct energy economy characterization is that MHD ZEVs have 5-50 percent higher energy efficiency on a Well-to-Wheels (WTW) basis.

Consequently, fueling HD diesels with 95% RD and 5% BD easily provides more annual CO_2e reductions than the range-limited battery HD ZEV. The LCFS reported cumulative RD and BD fuel credits are 3.5 times greater than the electric and hydrogen LCFS credits.[11] Today, RD and BD are displacing 22% of the petroleum diesel sold in California. RD and BD's CO_2 reductions continue to significantly outpace that of ZEVs. In 2019, 830 million gallons of BD and RD were sold in California, displacing petroleum fuel and providing CO_2e emissions reductions equivalent to that of 277,000 MHD ZEVs replacing diesel MHD vehicles.

Figure 6, below, shows the range of EERs estimated from the same Altoona Bus Emission Test Facility, vehicle population, and values CARB Staff used for their EER calculation. The EER range is shown relative to vehicle fuel economy, and the EER includes the battery charger and battery losses in accordance with TTW protocol. Most critically, the red line shows the WTW which is the proper metric to reference vehicle efficiency comparisons with electric vehicles. WTW analysis is often the legislatively mandated method required for state programs. The WTW metric includes the latest California Energy Commission (CEC) average power plant efficiency losses and power line losses for EV charging.

Figure 6. MHD ZEV Energy Efficiency Ratios vs Diesel Vehicle Fuel Economies



Source: Analysis of the Altoona Bus Emission Test Facility Results

[11] Per the ARB LCFS quarter reports through 4th quarter 2019, Biofuel Diesel total 25.5 million all electric and hydrogen vehicles total 7.2 million LCFS credits.

CARB Staff footnoted but do not appear to have incorporated the battery charger and round-trip battery losses in their EER calculation, graphics, and *ACT Fact Sheet*. Accounting for the 15 percent battery and charger losses that CARB staff cite in *Appendix G Battery Electric Truck and Bus Energy Efficiency Compared to Conventional Diesel Vehicles* lowers ZEVs' 2-5 times higher EER to 1.7 - 4.25 EER. Including power plants 45% efficiency and 6.5% power line losses lowers CARB Staff's estimated EER to 1.1-1.8 (WTW).

Given the above, I urge the Board to not adopt the ACT regulation and direct Staff to investigate the items raised before reconsidering the ACT regulation.

Thank You,

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